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05/80: Microcomputers in the Schools: New Directions for British Columbia

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MICROCOMPUTERS IN THE SCHOOLS:
NEW DIRECTIONS FOR BRITISH COLUMBIA

DISCUSSION PAPER

#05/80

Annette Wright
May, 1980

INDEX

INTRODUCTION

BACKGROUND

HARDWARE

COURSEWARE

IN-SERVICE

INFORMATION

CO-ORDINATION

CURRICULUM INTEGRATION/IMPLEMENTATION

SUMMARY

APPENDICES 1. REQUIREMENTS ANALYSIS OF AVAILABLE MICROCOMPUTERS

2. AUTHORING LANGUAGES FOR MICROCOMPUTERS

INTRODUCTION

The impetus for integrating computer-oriented activities into school curricula has arisen from two major sources:

1. the need to educate students about computers in general - their pervasiveness in society, their advantages and drawbacks (in short, computer literacy);

2. the potential uses of computer hardware and software as tools in the instructional process.

Recent refinements in computer technology, particularly microprocessor technology, have made computer augmented instruction a realistic and economic proposition. The machines which utilize this technology - microcomputers - have few of the drawbacks which often made older main-frame equipment infeasible for educational purposes.

There is a growing library of application software focused on curriculum objectives ("courseware"). In addition, both students and teachers can learn quickly to write programmes which will meet individual needs. Each machine can act as a terminal to a main-frame computer so that both information retreival and administrative applications are possible, or it can access programs and other information from tape or disk storage.

A pilot study is now underway in British Columbia for the large-scale introduction of micro-computers into the classrooms of the province. The purpose of this paper is to outline short-term plans for the educational use of microcomputers and to indicate long-term possibilities. The following material is summarized from the Instructional Use of Microcomputers Scope Document dated February 22, 1980.

BACKGROUND

Earlier this year, a proposal for a project relating to the instructional use of microcomputers was submitted to the MInistry of Education by JEM Research. Events leading up to the proposal are documented in three previous discussion papers - 10/79, 11/79, and 13/79. A related study which examined computer games and calculators, was discussed in a later paper (01/80). Another related study examining employment opportunities was covered in Discussion Paper 03/80.

The purpose of the project is to make available to the schools of British Columbia, the best in microcomputer hardware and software applications, as they become available, in a manner consistent with the requirements of the Ministry and the needs of teachers. The primary emphasis is integration of this technology into the provincial curriculum; at the same time, it is hoped that sub-projects will be developed to look at special needs situations in order to serve either atypical students or specific problem areas.

Initial directions for the pilot segment of the project were announced at a conference held in Vancouver on March 21, 1980. By this point, general support for the project from the education sector was well established; not only by the heavy positive response to the Discussion Papers, but by the fact that only approximately one third of those who wished to attend the conference could be accomodated.

The Apple II microcomputer was selected for the pilot study, largely because it was originally designed for educational purposes and has been tried and proven in the schools of Minnesota hence a series of course modules of interest to B.C. were available. By April 1980, arrangements were underway for the initial distribution of one hundred microcomputers to schools.

Six groups are involved in the evolution of the project:

The Ministry of Education - is providing funding and curriculum advice.

The British Columbia Systems Corporation - is responsible for the acquisition and distribution of microcomputers to the schools.

School Districts - have been involved in co-ordination and selection of participants.

Classroom Teachers - have been providing valuable feedback, suggestions and comments and those with microcomputer experience continue to be of great assistance.

The Universities and Colleges - are involved in the inservice and training aspects of the project.

JEM Research - is providing overall co-ordination for the project and the facilities for ongoing research, testing and evaluation of microcomputers (hardware) and programmes (courseware).

These various interests must be considered in order to successfully develop the Instructional Use of Microcomputers Project give some indication of its complexity and of what is involved in the co-ordination effort.

The remainder of this paper summarizes plans for each of these interests. Activities for carrying out each step of the project are well underway and are being undertaken in parallel. However, the project as a whole comprises two major phases:

PHASE I: continued field liaison and research;

PHASE II: curriculum integration and development.

HARDWARE

As a result of evaluation carried out by JEM Research, the APPLE II Microcomputer is the preferred hardware for the first phase of the project. (For a summary report see Appendix 1). At time of testing, the APPLE had advantages in portability and strength and the attraction of colour video. Some good instructional programmes (courseware) are already available from MECC for use and the APPLE can effectively be used as a terminal which will allow school districts to hook into local college on-line systems if they so wish. (Some testing has already taken place on this possibility). However, because new technology is constantly being made available, the evaluation of other microcomputers will continue and will be matched with the APPLE II field performance.

The interviews conducted at the beginning of the project, indicate that most respondents favoured the central co-ordination of equipment acquisition and distribution - largely so that a compatible basis would exist on which to evaluate pilot results. JEM has negotiated with the British Columbia Systems Corporation the possibility for acquiring and distributing the machines to the schools on behalf of Education.

Plans are being made to establish a broad basis for field-testing of the microcomputers and given that there are a limited number of machines, the following aspects are being considered:

1. the uses which teachers or groups of teachers plan for the equipment, remediation, tutorial, enrichment, literacy, computer science;
2. the context of the application; classroom, laboratory, resource centre, library;
3. location; urban, rural;
4. level; elementary, junior secondary, senior secondary.

Previous experience with microcomputers is not a factor, but those teachers who have computer experience will probably be of great assistance to the school staffs in their districts.

COURSEWARE

Making microcomputers available to teachers is a relatively simple matter compared with the problem of programme (courseware) availability. It is assumed that most teachers will want to start out with prepared material on disks until they are more familiar with the equipment and can learn to programme their own lessons or develop special applications. In some cases, teachers will wish to rely entirely on commercially or provincially prepared courseware to supplement other curriculum material.

A limited amount of good courseware is available from the Minnesota Educational Computing Consortium (MECC) specifically for use with the APPLE. Much of this courseware is gradually being "downloaded" from their main-frame CYBER system, which is used in Minnesota; there is some lag therefore, in its availability. New material is also being developed by MECC. Through arrangements made earlier this year, each programmed disk is sent to JEM Research as it is ready, where it is tested, evaluated an graded for use in British Columbia.

At the same time, JEM Research staff are acquiring courseware from other known commercial sources (publishers and vendors) for similar evaluation, in order to ensure that the highest

quality programmes are used in schools and to save time, money and effort on the part of teachers and school districts, who would otherwise have to order on a "sight-unseen" basis.

There are three major problems with commercially prepared courseware:

1. as yet, there is relatively little available;
2. what is available, is often of mediocre quality;
3. some of the good courseware requires adaptation to meet British Columbia requirements.

Instead of relying entirely on prepackaged courseware, therefore, a four fold approach is being taken by the projects.

1. The development of a standards manual for the evaluation of courseware acquired from all commercial sources is already underway. The evaluations, along with short descriptions, will be made available to teachers so that they can order material with a good understanding of what they are purchasing.
2. High quality commercial courseware which needs modification, will be adapted for use in the province by JEM Research, in conjunction with the Curriculum Development Branch of the Ministry of Education.
   New programmes will be developed, specifically to meet particular curriculum requirements.

4. Teachers will be encouraged to develop their own programmes through in-service participation and on a project basis through Ministry sponsorship.

JEM Research will remain a support function to each stage of this approach, so that the delay between teachers receiving machines and availability of a good supply of courseware is as short as possible and so that co-ordination can be facilitated readily.

A demonstration disk is currently being prepared for initial use in schools when the machines are distributed. This will provide some idea of the variety of programmes available.

Both programme evaluation and the selection of courseware for use in the pilot phase of the project, are carried out by teacher-researchers at the JEM Research laboratory and are based on earlier field tests of both hardware and programmes in a number of schools. In addition, examination of coursewriter languages is continuing. (See Appendix B for an account of authoring languages).

In general, four major concerns are addressed in the evaluation process:

1. quality control;
2. provincial requirements;
3. grade-level suitability;
4. appropriateness as basic, supplemental, enrichment or drill material for specific portions of the British Columbia curriculum.

Some other courseware, not directly related to curriculum requirements, has educational value as a motivational or recreational device. Initial on-site tests demonstrated that some of the games, for example, assisted children in Kindergarten and early elementary school with eye-hand co-ordination (using the game paddles for both horizontal and vertical movement), colour recognition (selecting different colours in order to continute a game or draw pictures), use of vocabulary (recognizing commands, questions and feedback) and concept development (following directions).

This type of material may be regarded as "remedial" or "re-inforcement" material in particular circumstances. Testing reveals that there may be significant psychological gains in its use in the classroom. With older children, the stigma attached to remediation is removed - in this case, the emphasis appears to be on the use of the computer, rather than on the content of the courseware. For young children, the microcomputer provides the opportunity to be creative - an opportunity which rarely exists, particularly for the slower learner. Easy to use colour, graphics and sound reinforce this process.

However, as with specific curriculum courseware, these materials also require quality control and grade-level assessment.

Subsequent discussion papers will examine the courseware situation and authoring in more detail.

IN-SERVICE

Field support for teachers will be required in a number of forms, the most important of which is in-service and training, particularly over the next two years. It is recognized that a wide range of expertise exists within the teaching profession where computers are concerned. However, for the purposes of the project it has been long felt that inexperienced teachers should not be penalized in the acquisition and use of equipment. The first requirement therefore, is a mechanism which will allow any teacher to set-up and operate a microcomputer.

JEM Research is acting as the catalyst to bring together university, institute and college personnel for organizational meetings at which a provincial in-service strategy will be developed. In the short-term, a one-week orientation course is planned for teachers in the summer of 1980 and tentative plans for a higher-level credit course are underway. The latter will enable participants to learn programming and specialized applications.

The communciation of in-service opportunities to teachers and the assessment of needs will take place on a continuous basis and through a number of means - publicity by Universities and colleges participating, communicating directly with school boards, through information published in the JEM Research newsletter "micro-Scope" and through feedback from course participants.

INFORMATION

In a province-wide effort, such as the project represents, regular channels of communications are essential so that classroom teachers can take advantage of the latest and best which microcomputer augmented instruction has to offer.

The JEM Research team has designed and written a monthly newsletter - "micro-Scope" - which will allow for the exchange of information on technological developments, in-service opportunities, conferences, upcoming events and microcomputer applications. It is hoped that educators will both read and contribute to the newsletter so that it will be recognized as the forum for microprocessor news in British Columbia education. Interest in receiving copies has already been expressed beyond the province.

Discussion papers are planned at various stages of the project, so that progress can be summarized and evaluation results passed on. This paper, for example, presents the activities which have already been started. Subsequent papers will look at such topics as computer literacy testing and courseware availability.

Regular feedback from those actually using microcomputers in classrooms, through the medium of the newsletter and response to the discussion papers, will allow the research team to anticipate teacher needs and problems.

CO-ORDINATION

The co-ordination centre for the project, established initially at JEM Research, is the facility which underlies most of the activities described earlier. It is here that hardware and software are acquired and tested in a laboratory setting. Materials and equipment from a number of sources must be tracked down, evaluated and documented; feedback from educators is studied and responded to; communication is maintained with the various agencies, groups and individuals involved with the project.

The main direction of the co-ordination effort, is to keep classroom teachers up-to-date on the latest courseware and technology and its implications for classroom use. The project will allow a state of preparedness to exist in the education sector so that quick responses can be made to new technology as it becomes available.

There is no expectation that all teachers must become computer experts in order to make use of the new resources, on the contrary microcomputers in the classroom should ease the burden of individualization and special needs and allow teachers to be more effective in the instructional process. Some will want to modify available courseware and others will want to become authors. The co-ordination centre is designed to eventually help all of these approaches.

CURRICULUM INTEGRATION/IMPLEMENTATION

The thrust of the project is to integrate the use of microcomputers into the existing provincial curriculum as tools for more effective instruction. Much of the original proposal, therefore, concentrated on the process by which this might be carried out. Because both integration and implementation are longer-term efforts, they represent Phase II of project activities.

The curriculum development guidleines issued by the Curriculum Development Branch, have been used as the basis for planning computer augmented instruction. The curriculum development model is shown in Figure 1. Traditionally, advisory committees and contract teams have been used in curriculum development and it is suggested that external consultative advice may be used in the same way. The advisory structure is shown in Figure 2.

K to 12 curriculum development is geared to a nine-year cycle and involves approximately ten steps (Figure 3). Implementation is based on a five year lead time from the first assessment until the schools start with the new material.

Figure 4 indicates that on the schedule for beginning the revision cycle, mathematics is the first provincial assessment opportunity for microcomputer courseware augmentation. Implementation occurs following the five year development cycle;

computer augmented math instruction, therefore would commence in 1985.

Implementation plans for the next five years (based on the curriculum revision cycle) are detailed in Figure 5.

In co-operation with the Curriculum Development Branch, JEM Research has defined an implementation model which accounts for microcomputer based materials and which is consistent with the existing five year cycle. Each of the tasks which comprise the cycle is shown in Figure 6. Production of microcomputer based courses to augment the curriculum, fits between tasks nine and ten of the development sequence. The production model is shown in Figure 7.

The latter stages of curriculum integration and development are divided as follows:

LEVEL 1 a) Elementaty Language Arts

b) Senior Music

LEVEL 2 Science 8-10

LEVEL 3 K-12 Math

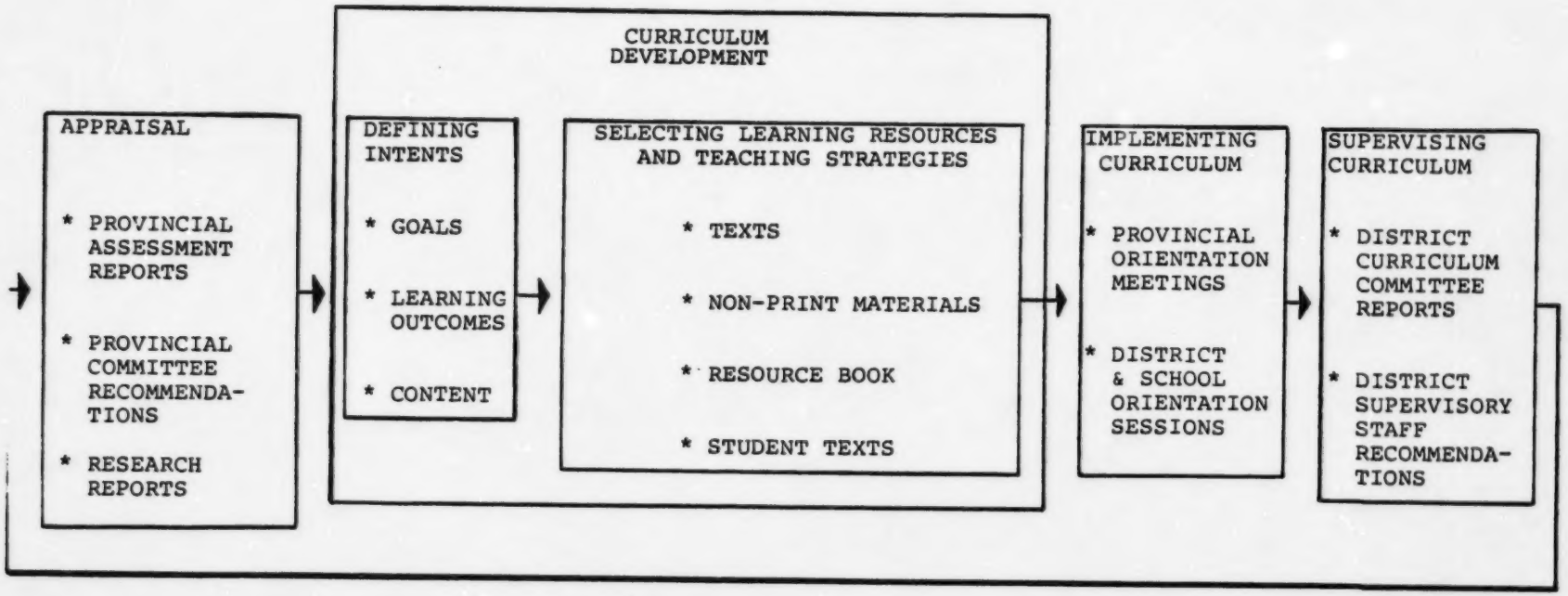
The reasons for the selection of these areas are that:

1. the first two modules are considered to be the best of the material presently available from MECC, and although lesson plans must be written and documentation improved, these items will be ready for testing in September, 1980. A series of Math lessons for Grades 1-6 may be added to this mode;
2. the Science 8-10 is a middle-level, lab-oriented programme and unique to British Columbia - implementation will begin in September, 1981. Discussions within co-ordinating committees has commenced.
3. the K-12 math programme represents a complete integration of an entire subject area, with planned implementation in September, 1985. Discussion within assessment committees has commenced.

Each of these activities will allow for experience to develop in different kinds of approaches - adaption of existing material, complete in-house development and full programme integration. This experience will provide valuable bases for further curriculum integration consistent with the nine year development/implementation cycle. The overall work plan for this project is shown in Figure 8.

Figure 1

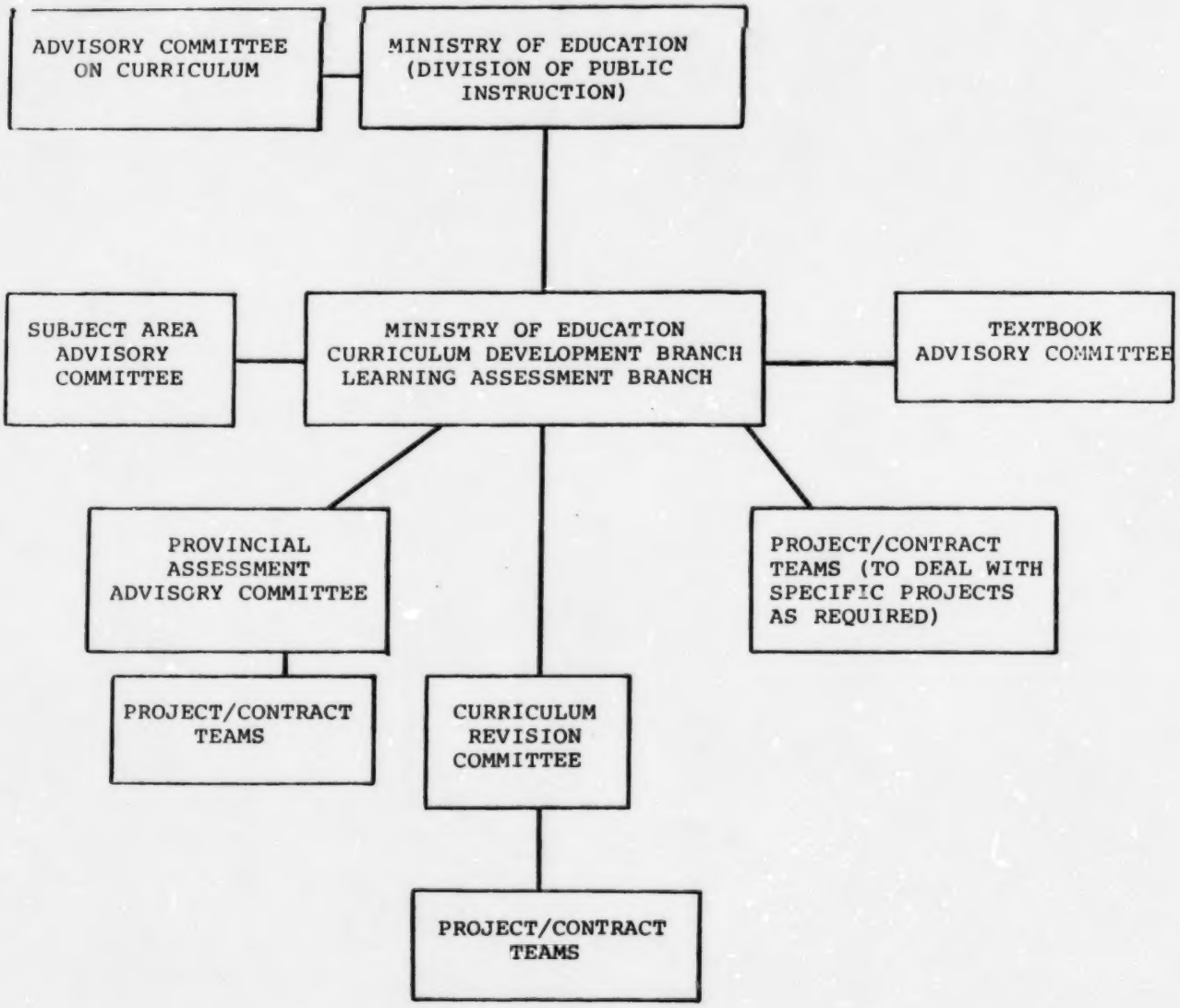
CURRICULUM DEVELOPMENT MODEL



Source: Curriculum Planning 1979

Figure 2

TYPES OF ADVISORY COMMITTEES

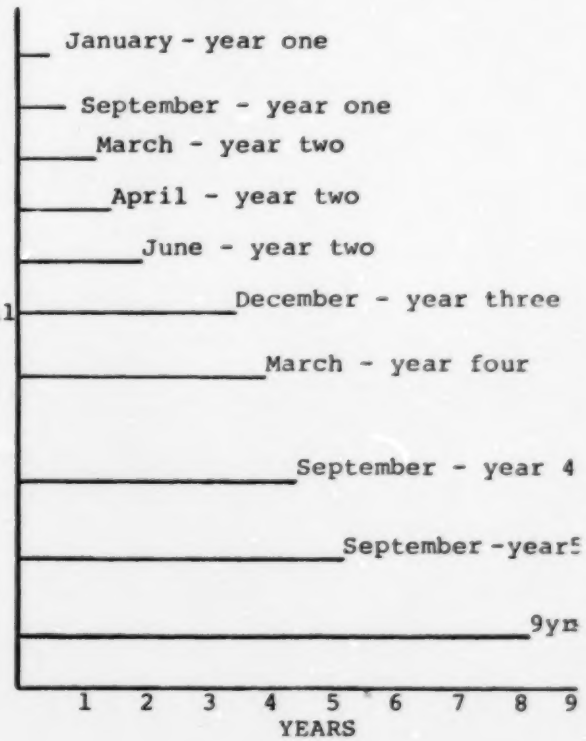

ADVISORY COMMITTEE ON CURRICULUM
MINISTRY OF EDUCATION (DIVISION OF PUBLIC INSTRUCTION)
SUBJECT AREA ADVISORY COMMITTEE
MINISTRY OF EDUCATION CURRICULUM DEVELOPMENT BRANCH LEARNING ASSESSMENT BRANCH
TEXTBOOK ADVISORY COMMITTEE
PROVINCIAL ASSESSMENT ADVISORY COMMITTEE
PROJECT/CONTRACT TEAMS (TO DEAL WITH SPECIFIC PROJECTS AS REQUIRED)
PROJECT/CONTRACT TEAMS
CURRICULUM REVISION COMMITTEE
PROJECT/CONTRACT TEAMS

Source: Curriculum Planning 1979
Curriculum Development
Branch

Figure 3

MAXIMUM TIME REQUIREMENTS: DEVELOPMENT AND IMPLEMENTATION OF K - 12 PROVINCIAL CURRICULUM

TASK	TIME
1. Assessment report reviewed. Revision committee formed.	January - year one
2. Statement of intent approved.	September - year one
3. Sequence of instruction prepared.	March - year two
4. Ministry approval of Sequence.	April - year two
5. Materials evaluation begins.	June - year two
6. Materials recommended for approval	December - year three
7. Ministry announcement to schools (guide and materials).	March - year four
8. Curriculum Summaries and Product Information booklets. Orientation begins.	September - year 4
9. Implementation of Curriculum in schools begins.	September - year 5
10. Assessment report reviewed. Next revision begins.	9yr



Source: Curriculum Planning 1979

Figure 4

TENTATIVE LONG-RANGE TIMETABLE
CURRICULUM DEVELOPMENT AND ASSESSMENT
NINE-YEAR CYCLE

YEAR	PROVINCIAL ASSESSMENT BEGINS	MAJOR REVIEW/REVISION BEGINS
1979	Kindergarten	Kindergarten
1980	Mathematics	Kindergarten
1981	Special Programmes	Mathematics
1982	Industrial Education	Special Programmes
1983	Language Arts (1-12)	Industrial Education
1984	Physical Education/French and Second Languages	Language Arts (1-12)
1985	Social Studies/Fine Arts	Physical Education/French and Second Languages
1986	Science/Home Economics	Social Studies/Fine Arts
1987	English as a Second Language/Business Education	Science/Home Economics
1988	Kindergarten/Guidance, Career and Occupational	English as a Second Language/ Business Education
1989	Mathematics	Kindergarten/Guidance, Career and Occupational Development
1990	Special Programmes	Mathematics

↓

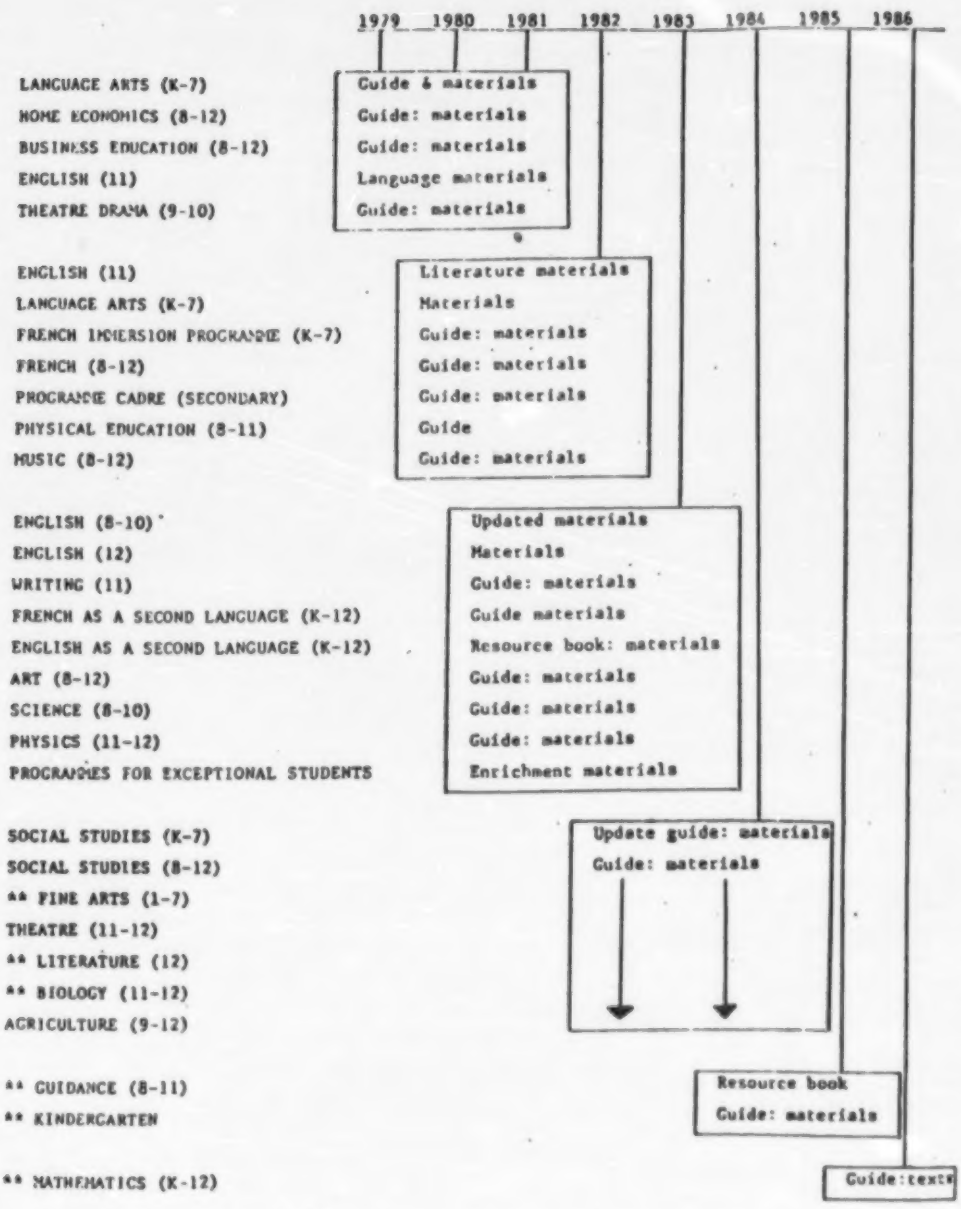
Cycle Continues

For example, in the Spring of 1980, planning for a Provincial Mathematics Assessment (1-12) will start. Assessment reports will be available in the fall of 1981 when a review / revision of the mathematics curriculum (1-12) will begin.

Source: Curriculum Planning 1979

Figure 5

* CURRICULUM IMPLEMENTATION PLANS



* The intention here is to indicate over what period of time curriculum guides and/or learning resources will become available for use in the classroom.

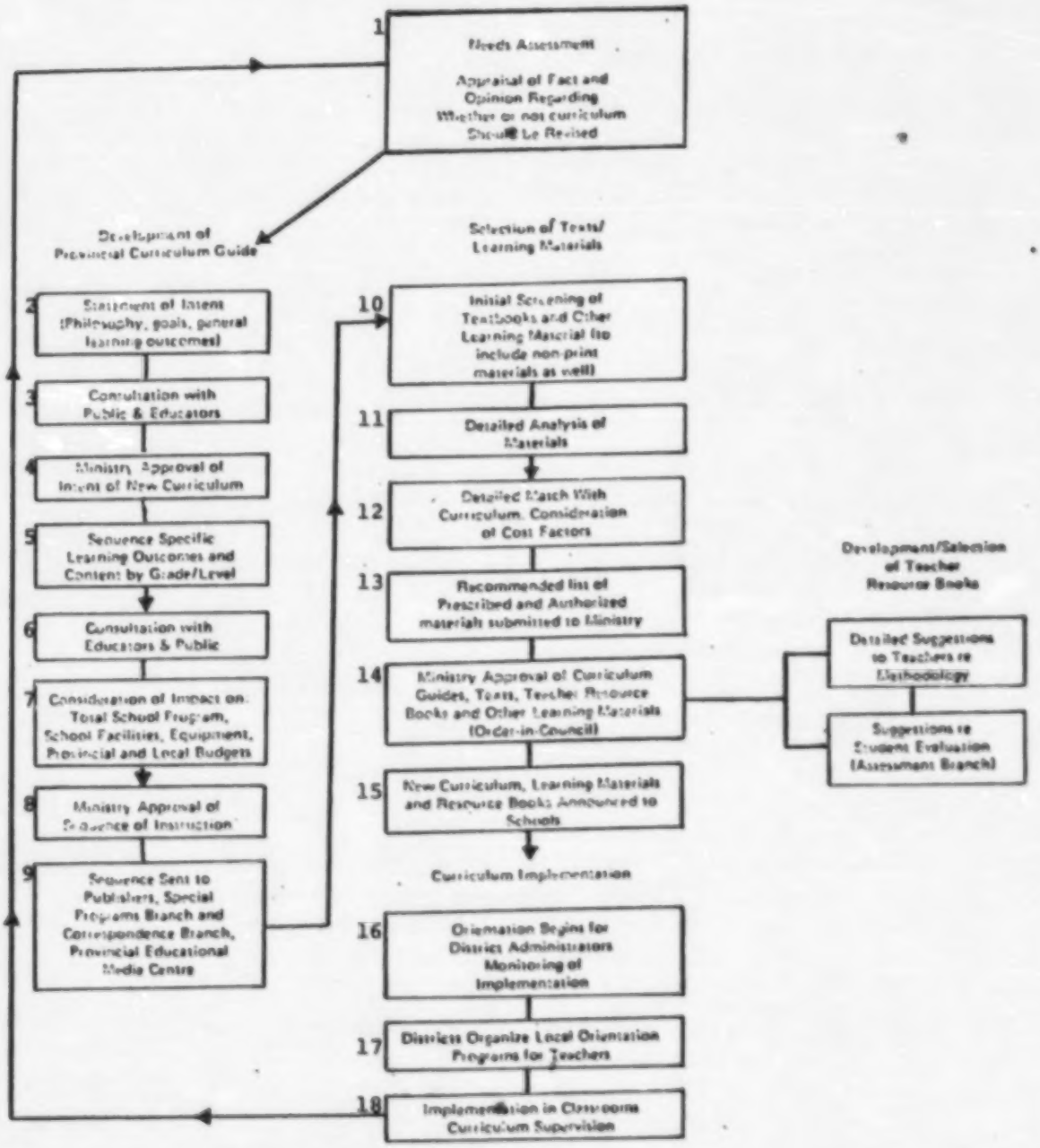
** Curriculum Committee not as yet formed.

Source: Curriculum Planning 1979

Figure 6

DEVELOPMENT OF PROVINCIAL CURRICULUM

SEQUENCE OF TASKS


1
Needs Assessment
Appraisal of Fact and Opinion Regarding Whether or not curriculum Should Be Revised
Development of Provincial Curriculum Guide
Selection of Texts/ Learning Materials
2
Statement of Intent (Philosophy, goals, general learning outcomes)
3
Consultation with Public & Educators
4
Ministry Approval of Intent of New Curriculum
5
Sequence Specific Learning Outcomes and Content by Grade/Level
6
Consultation with Educators & Public
7
Consideration of Impact on Total School Program, School Facilities, Equipment, Provincial and Local Budgets
8
Ministry Approval of Sequence of Instruction
9
Sequence Sent to Publishers, Special Programs Branch and Correspondence Branch, Provincial Educational Media Centre
10
Initial Screening of Textbooks and Other Learning Material (to include non-print materials as well)
11
Detailed Analysis of Materials
12
Detailed Match With Curriculum, Consideration of Cost Factors
13
Recommended list of Prescribed and Authorized materials submitted to Ministry
14
Ministry Approval of Curriculum Guides, Texts, Teacher Resource Books and Other Learning Materials (Order-in-Council)
15
New Curriculum, Learning Materials and Resource Books Announced to Schools
Curriculum Implementation
16
Orientation Begins for District Administrators Monitoring of Implementation
17
Districts Organize Local Orientation Programs for Teachers
18
Implementation in Classrooms Curriculum Supervision
Development/Selection of Teacher Resource Books
Detailed Suggestions to Teachers re Methodology
Suggestions re Student Evaluation (Assessment Branch)

Source: Curriculum Planning 1979

Figure 7

MODEL – PRODUCTION OF MICRO COMPUTER BASED COURSES

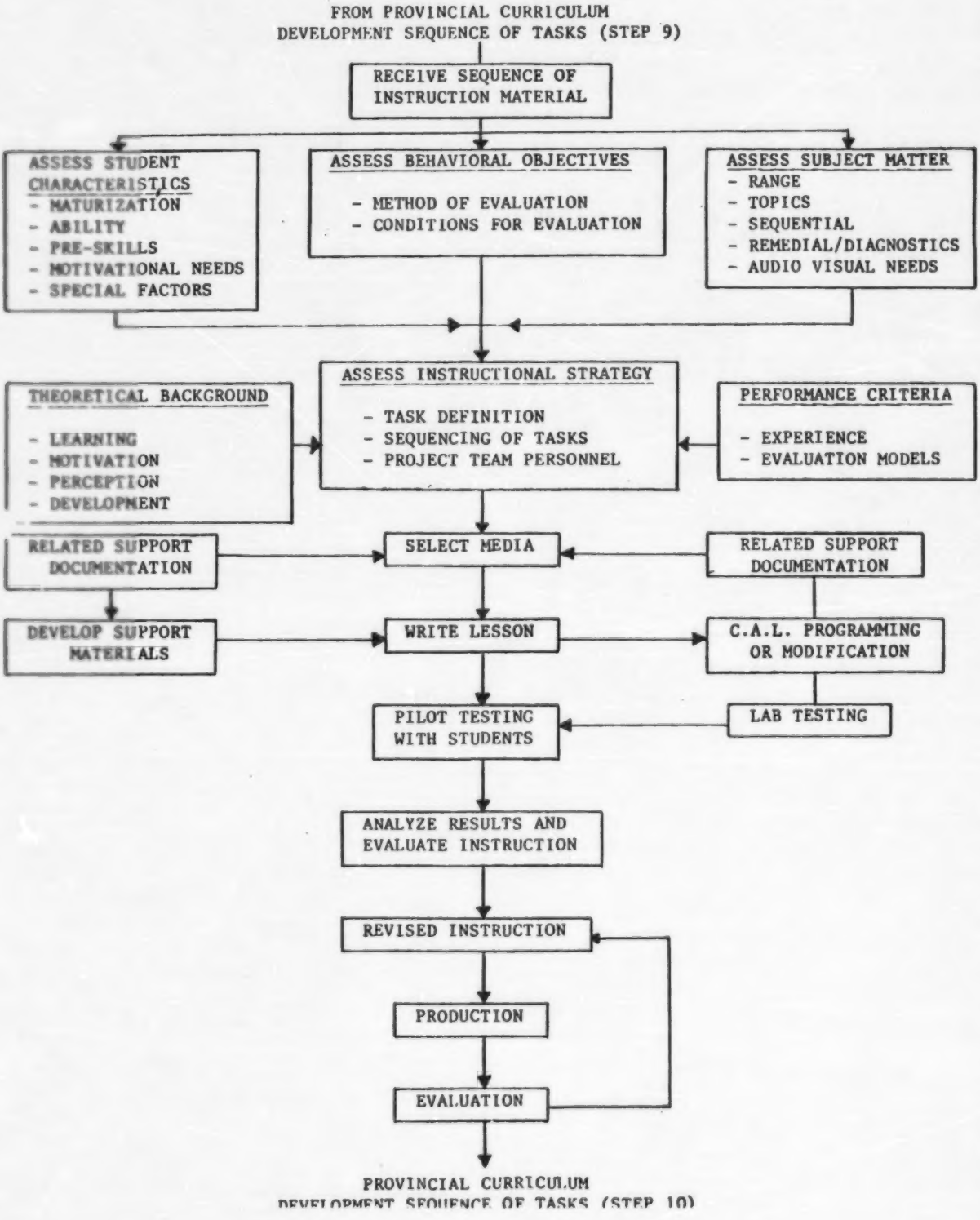
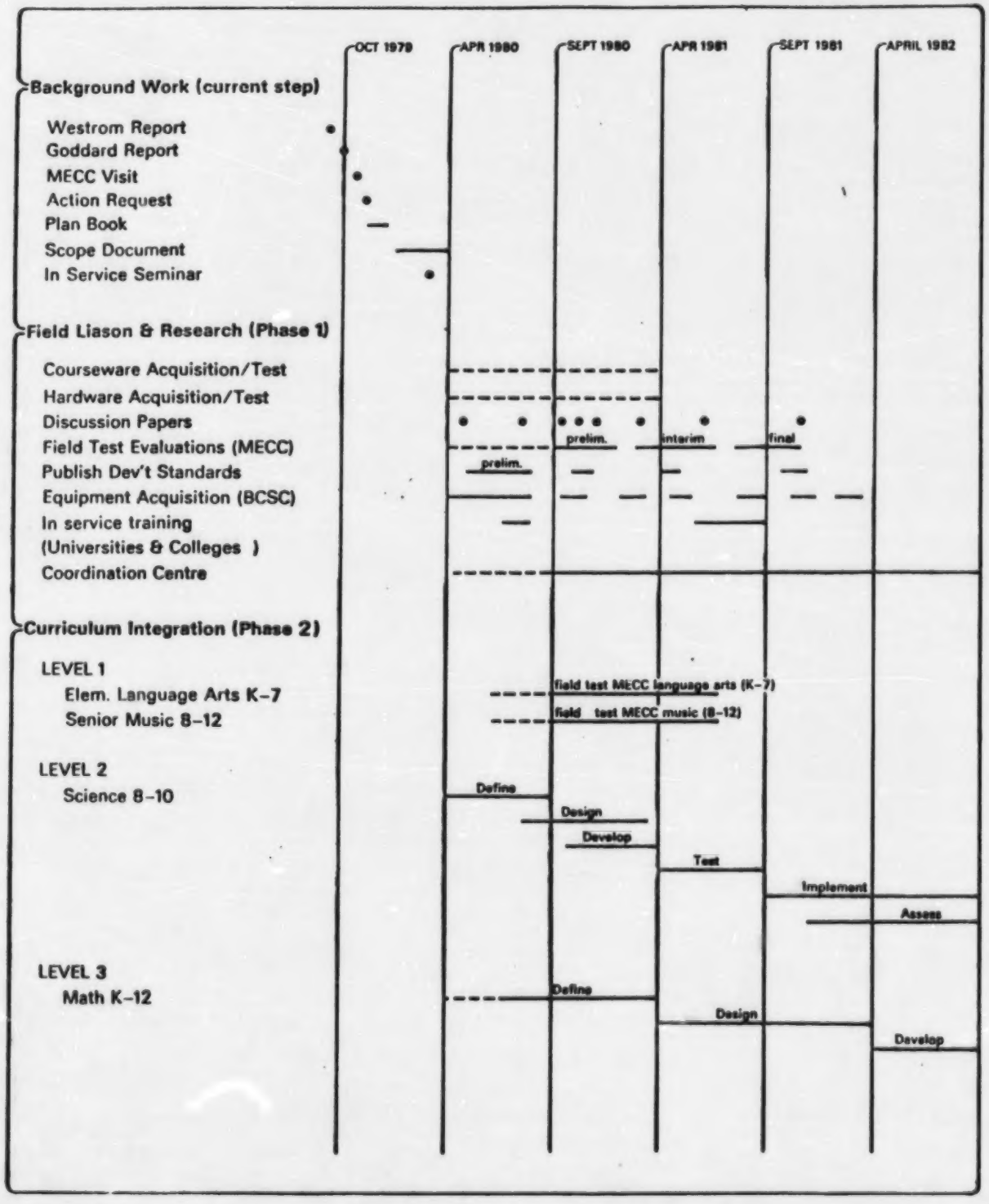


Figure 8

Instructional Uses of Microcomputers
Project Plan

jem research
Joint Educational Management Research



SUMMARY

This Discussion Paper has described the activities presently underway in the Instructional Use of Microcomputers Project. The field-test (pilot) phase of the project will begin in the schools in September, 1980. Evaluation of this phase will allow adjustment for further steps of the project and feedback for those teachers not involved in the pilot study.

Initial in-service requirements will be met with a summer orientation workshop for teachers; more advanced courses will be planned, based on needs, to cover programming and special applications. Further regional support is being planned.

Communication with the field will take place through a newsletter and a number of discussion papers. Curriculum integration is geared to mesh with the established cycle of revision, which will allow for gradual selection, adaption and development of curriculum materials to meet provincial requirements. All activities will be a co-operative effort among the Curriculum Development Branch, JEM Research and the education sector.

APPENDIX 1

REQUIREMENTS ANALYSIS OF AVAILABLE MICROCOMPUTERS

MINISTRY OF EDUCATION
JOINT EDUCATIONAL MANAGEMENT RESEARCH
INSTRUCTIONAL USE OF MICROCOMPUTERS
SCOPE DOCUMENT

REQUIREMENTS ANALYSIS OF AVAILABLE MICROCOMPUTERS

Summary of Findings Related To Hardware Configurations

There are three makes of microcomputers that are in fairly wide-spread use by educators in North America. These are the APPLE II, the Commodore "PET", and the Radio Shack "TRS-80". The APPLE II has several clear advantages over the other two makes and has accordingly been selected by a number of educational authorities as the vehicle for the development of their instructional courseware. The chief advantages of the APPLE II are:

a) that displayed material can be presented in a wide range of colours on standard T.V. screens, or on colour video monitors. The PET and the TRS-80 do not have any colour capability;

b) that high resolution graphics in any configuration can readily be programmed and can be controlled where appropriate by the pupil using simple external devices;

c) that the engineering design of the APPLE II allows a wide range of peripheral input-output devices such as microphone and speakers for speech, a light pen, graphics tablets and printers to be easily connected and readily used;

d) that firmware for the use of higher level languages beyond BASIC, including PASCAL, Micro-soft and LISP is already available for courseware writers;

e) that an RS232 interface is available so that the APPLE II can be readily used as a terminal for such networks as CHOICES, NATAL 74 and the CYBER 70 allowing for the downloading of complex software requiring greater memory and information banks than available to present stand alone microprocessors;

f) that the modular construction in high impact resistant plastic light weight housings, renders the APPLE II easily transportable without fear of damage to the equipment or physical harm to teachers or pupils.

MINISTRY OF EDUCATION
JOINT EDUCATIONAL MANAGEMENT RESEARCH
INSTRUCTIONAL USE OF MICROCOMPUTERS
SCOPE DOCUMENT

As the result of an earlier analysis conducted under the J.E.M. Project, a decision was made to acquire several APPLE II microcomputers together with the courseware developed by the Minnesota Educational Computer Consortium (MECC), and to assess the suitability of the material for use in B.C. schools. When the educational community became aware of this decision, through discussion papers circulated by J.E.M., several representations were made to J.E.M. by teachers and manufacturers' agents asking that the Commodore PET and its courseware also be evaluated. Subsequently, a Commodore PET was loaned to the J.E.M. Research laboratory and after a familiarization period, some of the available courseware has been demonstrated to J.E.M. personnel.

A review of the characteristics of the Radio Shack TRS-80 has shown that there is little advantage in a more detailed evaluation of the TRS-80 at this time because the available equipment and software is not as advanced for educational purposes as the other two equipments. Plans for further evaluation are however included in later stages of the project. A detailed first phase evaluation report covering the physical and electronic design characteristics of the APPLE II and the Commodore PET is now in preparation together with the evaluation report on the available courseware, but the present recommendation is that, because of the clear advantages and greater flexibility of the APPLE II at this point, arrangements should proceed to acquire a number of APPLE II microcomputers to utilize the advantages of computer aided and managed instruction in B.C. schools and to help the development of computer awareness and literacy.

It is recognized that rapid advances are being made in microcomputer technology so that giant strides will be made by all manufacturers, and from time to time, one or another will be ahead. At present, APPLE II is ahead and its design is sufficiently flexible to accommodate many foreseeable technological improvements as they take place. Nevertheless, it will be important to maintain a continuous evaluation of the state of the art on behalf of B.C. schools.

APPENDIX 2

AUTHORING LANGUAGES FOR MICROCOMPUTERS

AUTHORING LANGUAGES FOR MICROCOMPUTERS

Background

Many coursewriting and authoring languages have been developed for computer aided instruction when using large computers and computer-based education time-shared networks. One of the earliest of these languages was IBM's COURSEWRITER III which has been followed by York/APL, APLSV and more recently by IPS from Simon Fraser University. Control Data has developed the language TUTOR for use with PLATO on its CYBER 70 network and the Canadian National Research Council was responsible for the CAN series, CAN-6, CAN-7, CAN-8 and has now established NATAL-74, as a standard NATional Authoring Language on its DEC-10 network.

Although microcomputers can be used as terminals to access these large time-sharing networks, the majority of courseware available for use with stand-alone microcomputers has been written in the General Purpose Programming Language, BASIC, because the microcomputer manufacturers have embodied BASIC as the primary programming language in their microcomputers. Although BASIC is an excellent language to learn the art of programming, there are better languages available for microcomputers when any complexity or large data bases are required.

Some microcomputer manufacturers, notably APPLE, are now providing firmware for other General Purpose Programming Languages such as PASCAL which offers a better problem solving capability than BASIC because of its structured organization. There are also some languages specifically designed for authoring such as PILOT, which are being used by some educational authorities especially for the presentation of textual materials.

This Appendix attempts to give a brief run down on the subject of languages for microprocessors. An understanding of the role of the various languages available, and used in microcomputers, may assist educators in choosing suitable languages and firmware for developing their own courseware. There is little doubt that BASIC in its various versions will continue to be used for many years, but that PASCAL, PILOT and probably NATAL-74 will become of major importance for computer aided instruction in Canadian schools.

The University of Victoria is using a NATAL-74 terminal and is preparing the NATAL-74 textbook and manual for the National Research Council.

The following survey of languages commences with a brief description of the so-called low level languages - Machine and Assembly Language - before describing the higher level languages to assist the reader in understanding how the microcomputer is able to comprehend keyboard instructions.

Machine Language

Microcomputers operate electrically in what is known as machine language which comprises "bits" of data which are presented to the computer as "on" or "off" signals usually referred to as "ones" or "zeros". Very simple electrical circuitry can easily recognize whether a signal is present or absent, and a string of these ones and zeros can be assembled in a package or "byte" to represent any alphabetic, numeric or symbolic character merely by the sequence of ones and zeros. A series of eight ones and zeros can be arranged in 256 different ways and therefore can represent 256 different characters or positions of an element for generation of a symbolic character. These characters can also be stored or held in a computer memory by what may be considered as a set of switches, some of which are on while others are off.

The representation of data by a simple two number system comprising ones and zeros is known as binary digit arithmetic. A computer using this two state arithmetic is known as a digital computer. Analog information representing continuously variable physical quantities such as distance, speed, pressure and say pitch in the form of varying electrical voltage can be sampled, digitized and processed through a digital computer with the output displayed or presented in graphical or other physical format. The advantage of machine language is that binary pulses of data can be processed at the speed of light which is far beyond the human power of discrimination of pieces of data.

Assembly Language

Although software programmes for microcomputers can be written in machine language, it is a very tedious process because humans cannot easily read long strings of ones and zeros. Computer programmers have therefore developed methods by which the computer can recognize words typed in on a keyboard or through other input devices. The microcomputer keyboard usually uses the ASCII code for representing upper and lower case letters, numbers, symbols and punctuation marks. ASCII stands for American Standard Code for Information Interchange.

Each keyboard character can be represented by a seven bit code. For instance, a capital "A" is represented by 0001100 and a small "a" is 0001110. The ASCII code also covers a number of standard instructions to the computer such as DEL or 1111111 which signals "Delete" and BS or 1000000 which signals "Backspace". More complex programming commands are assembled in bytes from several alphabetic letters in a word or word abbreviation such as, LOAD or CLR for "Clear". Similar coding is used to create commands for the operation of programmes.

Assembly language requires considerable expertise to write and to maintain, but is very direct in operation because each Assemby language instruction becomes one machine language instruction. There is a MONITOR program in the APPLE II which carries out a similar function to an Assembler.

BASIC

BASIC is the language used for programming almost any microprocessor. The word is an acronym for Beginner's All-purpose Symbolic Instruction Code. Perhaps one can say that BASIC is one of the lowest of the so-called high level languages for communicating with a computer. Other well known computer languages COBOL, ALGOL and FORTRAN were each developed for fairly specific applications and each has its own complex rules. BASIC is a less powerful language with a limited vocabulary and only a few rules of grammar. The operating manual of each microprocessor instructs the user in the use of BASIC and in a short while the beginner is able to write simple programmes. There are about twenty principal words in the BASIC language that the computer recognizes. Some of these are - LOAD, SAVE, RUN, PRINT, REM ("Remark" abbreviated), GOTO, INPUT, IF/THEN, READ, DATA, GOSUB, FOR/NEXT, DIM (Dimension" abbreviated), LET, LIST and END.

In addition to the vocabulary, the punctuation marks all have specific interpretations by the microcomputer. Each programme has to be numbered so that it can be located in the computer memory, and when the programme is RUN each statement will be retrieved sequentially. The microcomputer has to convert these words and symbols into machine language as described above, before it can operate on the instructions.

There are several variations of the BASIC language. APPLE has two versions INTEGER BASIC and APPLESOFT. Both are more powerful than the original BASIC. The APPLESOFT language is derived from MICROSOFT which in turn was specifically developed for progamming microcomputers for computation where a floating decimal point is required. As the name indicates,

INTEGER BASIC deals with whole numbers and can be easily used for all textual programmes with simple low resolution graphics using fairly thick coarse lines and solid figures. APPLESOFT has to be used when thin graphic high resolution lines are required. The Commodore "PET" uses the standard BASIC with floating point arithmetic, but instead of generating point to point graphics it uses predefined graphic symbol characters, each of which is identified on the keyboard.

MICRO LISP

LISP is a well known computer language developed for LISt Processing and is largely used for what is known as artificial intelligence applications such as processing natural language input, performing symbolic differentiation and integration of numerical formulas and providing mathematical theorems. Micro Lisp is a microprocessor implementation of LISP and is available as an interpreter in the APPLESOFT BASIC. Micro Lisp is available for the APPLE II microcomputer and a detailed description of its use is contained in the APPLE Software Bank as a Contributed Programme in Volume 3 of that series.

PASCAL

Another powerful authoring language available for the APPLE microcomputer is PASCAL, named after the mathematician Blaise Pascal, and devised from the language ALGOL to overcome some of the problems and deficiencies of existing computer languages. PASCAL is claimed to provide speed, economy and power by structural programming. It is a procedure oriented language which means that the computer recognizes certain procedures by name and executes those procedures when it encounters the name of the procedure. PASCAL is essentially a problem solving language but it is claimed that learning PASCAL as a first computer language enables a student to think logically, systematically and creatively. APPLE PASCAL is implemented in the APPLE II as a "compiler" in contrast to BASIC which is implemented as an "interpreter". The difference in this context is that the compiler saves routines or procedures which can be accessed as often as needed whereas an interpreter scans each instruction and then runs it, but does not store it for later use. This feature enables disk storage to be used very effectively and frees the APPLE from the limitation of memory size.

PILOT

PILOT is an authoring language used in collaboration with a programming language such as BASIC and is available on Diskette for use on the APPLE II when a large amount of textual material is to be presented and a considerable data base is required for checking the students responses. The structure of PILOT is very simple in that one letter commands are used in formulating, constructing, editing and running the programme. There are 13 commands in the course "Editor". These are TOP, BOTTOM, NEXT, WHERE, PRINT, LOCATE, GCHANGE, DELETE, INSERT, REPLACE, CHANGE, HELP and QUIT. These are entered into the computer by the initial of the word plus a colon followed by the statement. Thus T: B: N: W: P: L: C: D: I: R: G: H: and Q:.

There are only a few programme commands. These are TEXT, ACCEPT and MATCH which can be followed by the suffixes Y and N to signify Yes or No, or Right or Wrong answer. T: can be a text statement followed by A: to obtain the student response followed by TY: or TN: with a comment by the computer. M: is a command to compare the response with the data bank of possible responses. PILOT also has provision for simple graphics which are called up by LINE, entered as L:, followed by the co-ordinates on the screen of the required line. The command PLAY, entered as P:, followed by a code number enables the APPLE microcomputer to play musical notes. The pre-programmed code numbers determine the duration, pitch and intervals of the musical notes. The grammar rules of PILOT are also very simple so that PILOT is easy to learn and to operate.

TUTOR

TUTOR and MICRO TUTOR are similar to PILOT in that they are designed for use with textual material. MICRO TUTOR has been designed for operation from a microcomputer terminal accessing the Control DATA PLATO language on a large time-shared network such as the CYBER 70. MICRO TUTOR has about 90 commands while TUTOR itself has nearly 400 commands. The programme commands are similar to the PILOT commands but using different words such as CONCEPT in place of MATCH - M:, DRAW in place of LINE - L:, ANSWER and WRONG in place of TY: and TN:

NATAL 74

NATAL 74, the NRC Authoring Language was developed by a working group at NRC under the direction of the Associate Committee on Instructional Technology. A functional

specification has been issued and a detailed specification then prepared under contract. The language is now implemented on the NRC DEC-10 computer.

NATAL-74 is a block structured language which incorporates three fundamental elements UNITS, PROCEDURES and FUNCTIONS. The UNIT element provides for the display of information and acceptance of input from specified peripherals together with general, edit and graphic functions which permit a complex exchange of information.

PROCEDURE provides for programme control, data gathering, processing and logical branching. NATAL-74 has also been implemented on an IBM 370/168 at the University of British Columbia where a course "Computers in Secondary Education" was successfully developed in 1977 around the NATAL-74 programme for the training of teachers in the teaching of Computer Studies in secondary schools.

A terminal for the NRC Ottawa DEC-10 has been placed in the Creative Writing Department at the University of Victoria and the Chairman of that Department has undertaken to prepare a textbook and manual for the use of NATAL-74.

There is little doubt that the successful use of NATAL-74 by two of the Universities of British Columbia will help to extend the use of this course authoring language in the Province. The J.E.M. Research laboratories have discussed the interface of the APPLE II to NATAL-74 with NRC Information Sciences personnel and have been encouraged to develop a proposal to implement the interface.

PREPARATION OF COURSES

The preparation of computer programmed instruction courses is a subject that has been undertaken by people of all ages and abilities. In many secondary and some primary schools, students with some relatively brief training have successfully prepared instruction courses and drills in spelling, language arts, mathematics, physics, music and other subjects for their teachers. The programming language BASIC, in one form or another, has been used by most course writers because it has been the primary language available on microcomputers that can readily be learnt by humans.

For stand-alone microcomputers, it is probable that the languages PASCAL and PILOT will in due course supplant BASIC, especially where large data banks and complex routines have to be called up. PASCAL will be chosen for mathematical and graphical routines and PILOT for textual material.

A large bank of computer aided instruction courses in a wide range of subjects is already available for microcomputers. Some have been written for use on the APPLE II and some designed for use on the Commodore "PET". Courses written for other microcomputers are also available but up to the present, none of these have been evaluated in the J.E.M. laboratories. The heart or central processor for both the APPLE II and the PET is a microprocessor solid state chip known as the 6502 and therefore much of the data processing is handled by both computers in a similar manner. The Radio Shack TRS-80 is designed around a different microprocessor known as the Z-80 and the computer architecture is rather different. However, although the APPLE and the PET use similar architecture and the same root language, BASIC, it is possible to run programmes developed for the PET on the APPLE or vice-versa. When graphical presentations are called up, a completely different technology is used by each machine and there are other changes in the retrieval of temporarily stored information that also render interchange of programmes unworkable.

For the purpose of initiating courseware, one approach would be to review the presently available courseware and to decide what changes the teacher would make to the most suitable readily available programmes. If this appears to be a possibility a hard, that is printed, copy of the LIST of programme statements should be obtained. It may then be possible to make the required changes by loading the program into the computer memory and retype those lines that need alteration. The programmes can then be SAVEd, that is put back on to a disk or cassette in its changed format. The procedure of retyping a numbered program line automatically

deletes the original line. Changing existing programmes to meet specific requirements is a quick method of learning something about programming. The procedure of loading the old programme into memory, reworking selected lines, then saving each version until a satisfactory programme has been accomplished, allows the re-writer to keep the original and intermediate versions and to test or RUN each change as it is made. Changes can of course be made to the LOADed program by retyping programme lines without printing the hard copy, but a careful review of the listing will reveal the possible effect of each change on subsequent computer instructions.

An example of a typical course that can easily be rewritten would be one on the State capitals in the U.S. Substituting the names of the Provinces and inserting the appropriate names of the Provincial Capitals should be straight forward. Similarly many of the comments on student performance prepared for one local culture may be inappropriate in another setting and these can easily be changed.

The coursewriter will be able to tackle more complex technical changes such as changes to DATA and the presentation of different graphical information after some experience with the simpler modifications.

Examples of programmes written by Junior Secondary School students are included with this report. Most of these have been developed on the lines discussed above, that is, using earlier programmes as models.

The J.E.M. Research laboratories has prepared a critical evaluation of the available courseware prepared by educational and commercial organizations and expect to develop courseware for use in B.C. schools based on the findings. Such new courseware will be developed in close collaboration with teachers and educators. Special courseware is already under development at the laboratories to implement the use of alternatives to the keyboard as input devices for instructional technology such as voice input, light pen, touch sensitive screens and graphic tablets.